REPLACED BY ART. 34 AMDT

PATENT COOPERATION TREATY

PCT

REC'D 07 NOV 2001
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/70036.WOP/LML		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/03375	01/09/2000	01/09/1999
International Patent Classification (IPC) or national classification and IPC H02K1/20		
Applicant ALSTOM UK LTD et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
24/03/2001	05.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Torlai, P Telephone No. +49 89 2399 2293

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03375

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1,4-14	as originally filed	
2,3	with telefax of	10/09/2001

Claims, No.:

11-20	as originally filed	
1-10	with telefax of	10/09/2001

Drawings, sheets:

1/4-4/4	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-20
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-20
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

1) Reference is made to the following document:

D1: GB-A-1 218 774 (GENERAL ELECTRIC) 13 January 1971 (1971-01-13)

2) Document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows an electrical machine with the features of the preamble of claim 1.
The machine comprises a matrix of coolant duct sections extending circumferentially and axially of the laminated core sections. The matrix is represented by the outlet sections 18, the inlet sections 20 and the communication channels or cylindrical pipes 24).
The matrix has a first face represented by the stator outer surface and second radially spaced apart face represented by the casing inner surface (2).
From picture 1 of D1 it is cleat that the coolant supply and exhaust means are arranged axially and that the second (outer) face (2) of the matrix is a close surface without radial apertures.

3) The subject matter of claim 1 differs from the machine known from D1 in that the second face is in fluid communication with the coolant exhaust duct means (26), such that selected of the coolant duct sections (5) communicate directly with the coolant exhaust duct moans (26) through the second face of the matrix.

Claim 1 says, in effect, that the first face of the matrix communicates with the stator core passages and the second face of the matrix communicates with the coolant exhaust ducts and that some of the coolant duct sections in the matrix communicate directly with the coolant exhaust duct through the second (i.e., for stator cores, radially outer) face of the matrix.
Though D1 discloses direct communication of cooling duct sections with stator core passages, it doesn't disclose direct communication of cooling duct sections with coolant exhaust ducts through the second face of the matrix.

For this reason document D1 does not disclose a matrix of coolant duct sections

with the same characteristics as defined in claim 1 and the subject matter of claim 1 is novel.

4) The problem to be solved may be regarded as to modify the the electrical machine known from D1 in order to make it suitable for use in situations where cooling air must be conveyed away from the machine in a non axial direction (see picture 4 of the present application).
The features of the characterizing part are not disclosed in the remaining documents of the available prior art.
Therefore the combination of the features of independent claim 1 is neither known from, nor rendered obvious by, the available prior art.

5) Dependent claims:
Claims 2- 20 include the features of claim 1. Therefore also the subject matter of these claims is new and involves an inventive activity.

6) Industrial application
The claimed invention is considered as susceptible of industrial application.

Re Item VII

7) The features of the claims 6-20 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

8) Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

passageways will adjoin with the air gap between the rotor and stator. Our published patent document GB 2 338 350 A discusses how to define such passageways more advantageously in terms of the cooling effect they can produce.

Whilst such an arrangement allows the passage of cooling fluid from the inside to the outside (or from the outside to the inside) of the rotor or stator, it has been found that the cooling effect that is provided is insufficiently controlled to produce even cooling over the entire circumferential and axial extent of the rotor or stator. In an electrical rotating machine even cooling is essential in order to avoid localised overheating of windings, thus enabling increased power densities to be obtained.

It is an object of the present invention to provide an arrangement whereby a more controlled cooling of the machine can be achieved.

Accordingly, the invention provides an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator or the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the radial passageways being connected to the coolant supply duct means *via* the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, the matrix having first and second radially spaced apart faces respectively in fluid communication with the

radially extending coolant passageways in the laminated core section and the coolant exhaust duct means, wherein selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

In one possible arrangement of the machine, the first and second radially spaced apart faces of the duct matrix comprises its radially inner and outer faces respectively.

The matrix of coolant duct sections is conveniently defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the core section. To facilitate the transfer of coolant in the predetermined path within the coolant duct matrix, apertures are provided in selected of the side walls and end walls of the coolant duct sections. The size and number of the apertures are preferably selected to achieve desired axial and circumferential pressure differences within the coolant duct matrix. It is possible that each side wall and each end wall will have a respective aperture, but this will be determined by detailed design using computational flow analysis.

In a preferred embodiment of the invention, in which the coolant duct sections are defined as above, a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

The end walls may be equi-angularly spaced around the laminated core section.

CLAIMS

1. An electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator or the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the coolant passageways being connected to the coolant supply duct means through the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, the matrix having first and second radially spaced apart faces respectively in fluid communication with the radially extending coolant passageways in the laminated core section and the coolant exhaust duct means, wherein selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

2. An electrical machine according to claim 1, in which the first and second radially spaced apart faces of the duct matrix comprises its radially inner and outer faces respectively.

3. An electrical machine according to any preceding claim, in which the matrix of coolant duct sections is defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the core section.

4. An electrical machine according to claim 3, in which apertures are provided in selected of the side walls and end walls of the coolant duct sections to facilitate the transfer of coolant in the predetermined path within the coolant duct matrix.

5. An electrical machine according to claim 4, in which the size and number of the apertures are selected to achieve desired axial and circumferential pressure differences within the coolant duct matrix.

6. An electrical machine according to claim 4 or claim 5, in which each side wall and each end wall has a respective aperture.

7. An electrical machine according to any one of claims 3 to 6, in which a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

8. An electrical machine according to any one of claims 3 to 7, in which the end walls are equi-angularly spaced around the laminated core section.

9. An electrical machine according to any preceding claim, in which each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

10. An electrical machine according to any preceding claim, in which the coolant supply duct means defines a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 May 2001 (29.05.01)	
International application No. PCT/GB00/03375	**Applicant's or agent's file reference** P/70036/LML
International filing date (day/month/year) 01 September 2000 (01.09.00)	**Priority date** (day/month/year) 01 September 1999 (01.09.99)
Applicant GLEW, Charles, Neville	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   24 March 2001 (24.03.01)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Zakaria EL KHODARY

Telephone No.: (41-22) 338.83.38

INTERNATIONAL SEARCH REPORT

Interr nal ation No
PCT/GB 00/03375

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K1/20 H02K9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 1 218 774 A (GENERAL ELECTRIC) 13 January 1971 (1971-01-13) page 2, line 21 - line 62 figure 1	1,2, 9-11,13, 18,19 14-17,20
Y	US 3 171 996 A (GENERAL ELECTRIC) 2 March 1965 (1965-03-02) column 3, line 45 - line 75 figures 1-6	14-17
Y	EP 0 590 867 A (KVAERNER MASA YARDS OY) 6 April 1994 (1994-04-06) claim 1 figure 2	20

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2000	11/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Foussier, P

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr ıal A ion No
PCT/GB 00/03375

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 1 792 720 A (ALLIS-CHALMERS MANUFACTURING) 17 February 1931 (1931-02-17)	

INTERNATIONAL SEARCH REPORT

...ormation on pate...amily members

Interr ...al ...tion No
PCT/GB 00/03375

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1218774 A	13-01-1971	CH 504803 A	15-03-1971
		DE 1814431 A	24-07-1969
		FR 1599338 A	15-07-1970
		US 3461330 A	12-08-1969
US 3171996 A	02-03-1965	NONE	
EP 0590867 A	06-04-1994	FI 924334 A	29-03-1994
		CA 2107202 A	29-03-1994
		DE 69302348 D	30-05-1996
		DE 69302348 T	26-09-1996
		DK 590867 T	12-08-1996
		ES 2087662 T	16-07-1996
		JP 6191484 A	12-07-1994
		NO 933441 A	29-03-1994
		RU 2097266 C	27-11-1997
		SG 43165 A	17-10-1997
		US 5403216 A	04-04-1995
US 1792720 A	17-02-1931	NONE	

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

DARGAVEL, Laurence, Peter
Alstom UK Ltd.
Mill Road
P.O. Box 70
Rugby
Warwickshire CV21 1TB
ROYAUME-UNI

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
17 October 2000 (17.10.00)	
Applicant's or agent's file reference	**International application No.**
P/70036/LML	PCT/GB00/03375

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

ALSTOM UK LTD. (for all designated States except US)
GLEW, Charles, Neville (for US)

International filing date	:	01 September 2000 (01.09.00)
Priority date(s) claimed	:	01 September 1999 (01.09.99)
Date of receipt of the record copy by the International Bureau	:	27 September 2000 (27.09.00)
List of designated Offices	:	

EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
National :JP,US

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Eugénia Santos

Telephone No. (41-22) 338.83.38

OK file

PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

DARGAVEL, Laurence, Peter
Alstom UK Ltd.
Mill Road
P.O. Box 70
Rugby
Warwickshire CV21 1TB
ROYAUME-UNI

Date of mailing (day/month/year) 26 October 2000 (26.10.00)	
Applicant's or agent's file reference P/70036/LML	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/03375	International filing date (day/month/year) 01 September 2000 (01.09.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 01 September 1999 (01.09.99)
Applicant ALSTOM UK LTD. et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
01 Sept 1999 (01.09.99)	9920581.7	GB	05 Octo 2000 (05.10.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Somsak Thiphrakesone

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
DARGAVEL, Laurence, Peter
Alstom UK Ltd.
Mill Road
P.O. Box 70
Rugby
Warwickshire CV21 1TB
ROYAUME-UNI

Date of mailing (day/month/year) 08 March 2001 (08.03.01)		
Applicant's or agent's file reference P/70036/LML	**IMPORTANT NOTICE**	
International application No. PCT/GB00/03375	**International filing date** (day/month/year) 01 September 2000 (01.09.00)	**Priority date** (day/month/year) 01 September 1999 (01.09.99)
Applicant ALSTOM UK LTD. et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   EP,GB,JP

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   08 March 2001 (08.03.01) under No. WO 01/17094

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

DARGAVEL, Laurence P.
ALSTOM UK LIMITED
PO Box 70, Mill Road
Rugby, Warwickshire CV21 1TB
GRANDE BRETAGNE

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	08.08.2001
REPLY DUE	**within 1 month(s)** from the above date of mailing

Applicant's or agent's file reference	International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
P/70036.WOP/LML	PCT/GB00/03375	01/09/2000	01/09/1999

International Patent Classification (IPC) or both national classification and IPC

H02K1/20

Applicant

ALSTOM UK LTD et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I	☒	Basis of the opinion
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☒	Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain document cited
VII	☒	Certain defects in the international application
VIII	☒	Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

08/09/01 redline

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis. For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 01/01/2002.

Name and mailing address of the international preliminary examining authority:

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer / Examiner

Torlai, P

Formalities officer (incl. extension of time limits)

Choulouilidou, C

Telephone No. +49 89 2399 2257

WRITTEN OPINION

International application No. PCT/GB00/03375

I. Basis of the opinion

1. With regard to the **elements** of the international application (Replacement *sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

Description, pages:

1-14 as originally filed

Claims, No.:

1-20 as originally filed

Drawings, sheets:

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-4
Inventive step (IS)	Claims	
Industrial applicability (IA)	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item V

Reference is made to the following documents:

D1: GB-A-1 218 774 (GENERAL ELECTRIC) 13 January 1971 (1971-01-13)
D2: US-A-3 171 996 (GENERAL ELECTRIC) 2 March 1965 (1965-03-02)
D3: EP-A-0 590 867 (KVAERNER MASA YARDS OY) 6 April 1994 (1994-04-06)

Document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document)
an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising ; coolant supply duct means and coolant exhaust duct means, a plurality of substantially radially extending coolant passageways (19, 12) provided in a laminated core section of at least one of the stator or the rotor, the coolant passageways being defined between axially spaced stacks of laminations (see column 2, lines 21 to 26) in the laminated core section, the coolant passageways being connected to the coolant supply duct means through the gap between the stator and the rotor, and a matrix of coolant duct sections extending circumferentially and axially of the laminated core sections (the matrix is represented by the outlet sections 18, the inlet sections 20 and the communication channels or cylindrical pipes 24) the matrix having first and second radially spaced apart faces (represented by the stator outer surface and by the casing inner surface) respectively in fluid communication with the radially extending coolant passageways in the laminated core section and the coolant exhaust duct means.
Selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix (surface of the casing); a plurality of adjacent coolant duct sections (18) are in fluid communication (passages 24 see column 2, line 37 to line 50)with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

Therefore the machine described in D1 shows all the essential features of claim 1 so that the subject matter of claim 1 is not considered to be new.

The attention of the applicant is also drawn to document D2 that describes a machine with the essential features of claim 1, wherein the matrix if is represented by the

plurality of apertures provided in the casing for the flow of the coolant.

Furthermore it is observed that the electrical machine according to D1 also shows the essential features of dependent claims 2 (see picture 1), 3 and 4.
In fact the machine according to D1 also shows a matrix of coolant duct sections with a plurality of annular side walls (22) (see also the annular regions at the radially internal side a of channels 24) which extend radially and circumferentially of the laminated core section and a plurality of end walls; apertures are provided in selected of the side walls of the coolant duct sections to facilitate the transfer of coolant in the predetermined path within the coolant duct matrix.

The combination of the features of dependent claim 5 is neither known from, nor rendered obvious by, the available prior art.
The problem to be solved can be regarded as to improve the machine known from D1 in order to obtain a more efficient cooling of the machine.
The features of claim 5 also seem to be essential for the solution a of the problem (**Re Item VIII**) to provide an arrangement whereby a more controlled cooling of the machine can be achieved and to produce even cooling over the entire circumferential and axial extent of the rotor or stator as Indicated in the description at page to, paragraph 2.

By means of the features of claim 5 the desired axial and circumferential pressure differences within the coolant duct matrix can be achieved.
As explained in the description that page 11, last paragraph by careful design of the size of the openings 11,12 in the walls 9, 9' and 10 of the duct sections, as well as the spacing and size of adjacent duct sections, accurate control of the cooling of the stator can be achieved to ensure a predetermined efficient cooling pattern is maintained. This accuracy of control has been found to be considerably more refined than a design in which the coolant duct matrix is omitted.

For this reason the combination of features of claim 5 is considered to be both clear and inventive.

The applicant is requested to file new claims which take account of the above comments.

Re Items VII and VIII

To meet the requirements of Rule 6.3(b) PCT the independent claims should be properly cast in the two part form, with those features which in combination are part of the prior art (see document D1) being placed in the preamble.

The features of the claims should be provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

The applicant will have to bring the description into conformity with the new claims; care should be taken during revision, especially of the introductory portion including any statement of problem or advantage, not to add subject-matter which extends beyond the content of the application as originally filed, (Article 34(2)(b) PCT).

To meet the requirements of Rule 5.1(a)(ii) PCT, the document D1 as well as the other relevant documents D2 and D3 should be identified in the description and the relevant background art disclosed therein should be briefly discussed.

The applicant is requested to file amendments by way of replacement pages. He should also take into account the requirements of Rule 66.8 PCT. In particular, fair copies of the amendments should preferably be filed in triplicate.

In order to avoid unnecessary comparison reading it would be appreciated if additionally to the amended replacement pages also the original pages with amendments in handwriting were enclosed in the letter of reply.

Moreover, the applicant's attention is drawn to the fact that, as a consequence of Rule 66.8(a) PCT the examiner is not permitted to carry out any amendments under the PCT procedure, however minor these may be.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

DARGAVEL, Laurence P.
ALSTOM UK LIMITED
PO Box 70, Mill Road
Rugby, Warwickshire CV21 1TB
GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	05.11.2001
Applicant's or agent's file reference P/70036.WOP/LML	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/03375	01/09/2000	01/09/1999

Applicant
ALSTOM UK LTD et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Fasbender, A Tel.+49 89 2399-2380

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/70036.WOP/LML		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/03375	01/09/2000	01/09/1999
International Patent Classification (IPC) or national classification and IPC		
H02K1/20		
Applicant		
ALSTOM UK LTD et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
24/03/2001	05.11.2001
Name and mailing address of the international preliminary examining authority:	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Torlai, P Telephone No. +49 89 2399 2293

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03375

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1,4-14	as originally filed	
2,3	with telefax of	10/09/2001

Claims, No.:

11-20	as originally filed	
1-10	with telefax of	10/09/2001

Drawings, sheets:

1/4-4/4	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-20
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-20
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

1) Reference is made to the following document:

D1: GB-A-1 218 774 (GENERAL ELECTRIC) 13 January 1971 (1971-01-13)

2) Document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows an electrical machine with the features of the preamble of claim 1.
The machine comprises a matrix of coolant duct sections extending circumferentially and axially of the laminated core sections. The matrix is represented by the outlet sections 18, the inlet sections 20 and the communication channels or cylindrical pipes 24).
The matrix has a first face represented by the stator outer surface and second radially spaced apart face represented by the casing inner surface (2).
From picture 1 of D1 it is cleat that the coolant supply and exhaust means are arranged axially and that the second (outer) face (2) of the matrix is a close surface without radial apertures.

3) The subject matter of claim 1 differs from the machine known from D1 in that the second face is in fluid communication with the coolant exhaust duct means (26), such that selected of the coolant duct sections (5) communicate directly with the coolant exhaust duct moans (26) through the second face of the matrix.

Claim 1 says, in effect, that the first face of the matrix communicates with the stator core passages and the second face of the matrix communicates with the coolant exhaust ducts and that some of the coolant duct sections in the matrix communicate directly with the coolant exhaust duct through the second (i.e., for stator cores, radially outer) face of the matrix.
Though D1 discloses direct communication of cooling duct sections with stator core passages, it doesn't disclose direct communication of cooling duct sections with coolant exhaust ducts through the second face of the matrix.

For this reason document D1 does not disclose a matrix of coolant duct sections

with the same characteristics as defined in claim 1 and the subject matter of claim 1 is novel.

4) The problem to be solved may be regarded as to modify the the electrical machine known from D1 in order to make it suitable for use in situations where cooling air must be conveyed away from the machine in a non axial direction (see picture 4 of the present application).
The features of the characterizing part are not disclosed in the remaining documents of the available prior art.
Therefore the combination of the features of independent claim 1 is neither known from, nor rendered obvious by, the available prior art.

5) Dependent claims:
Claims 2- 20 include the features of claim 1. Therefore also the subject matter of these claims is new and involves an inventive activity.

6) Industrial application
The claimed invention is considered as susceptible of industrial application.

Re Item VII

7) The features of the claims 6-20 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

8) Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

passageways will adjoin with the air gap between the rotor and stator. Our published patent document GB 2 338 350 A discusses how to define such passageways more advantageously in terms of the cooling effect they can produce.

Whilst such an arrangement allows the passage of cooling fluid from the inside to the outside (or from the outside to the inside) of the rotor or stator, it has been found that the cooling effect that is provided is insufficiently controlled to produce even cooling over the entire circumferential and axial extent of the rotor or stator. In an electrical rotating machine even cooling is essential in order to avoid localised overheating of windings, thus enabling increased power densities to be obtained.

It is an object of the present invention to provide an arrangement whereby a more controlled cooling of the machine can be achieved.

Accordingly, the invention provides an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator and the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the radial passageways being connected to the coolant supply duct means *via* the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, a plurality of adjacent coolant duct sections being in fluid communication with each other transverse of the

radial direction to transfer coolant in predetermined paths within the coolant duct matrix, the matrix having first and second radially spaced apart faces, the first face being in fluid communication with the radially extending coolant passageways in the laminated core section, characterised in that the second face is in fluid communication with the coolant exhaust duct means, such that selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix.

In one possible arrangement of the machine, the first and second radially spaced apart faces of the matrix of coolant duct sections comprises its radially inner and outer faces respectively.

The matrix of coolant duct sections is conveniently defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the laminated core section. To facilitate the transfer of coolant in the predetermined path within the coolant duct matrix, apertures are provided in selected of the side walls and end walls of the coolant duct sections. The size and number of the apertures are preferably selected to achieve desired axial and circumferential pressure differences within the matrix of coolant duct sections. It is possible that each side wall and each end wall will have a respective aperture, but this will be determined by detailed design using computational flow analysis.

In a preferred embodiment of the invention, in which the coolant duct sections are defined as above, a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

The end walls may be equi-angularly spaced around the laminated core section.

CLAIMS

1. An electrical machine (1) comprising a stator (2) and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means (22) and coolant exhaust duct means (26),

a plurality of substantially radially extending coolant passageways (15) provided in a laminated core section (3) of at least one of the stator and the rotor, the coolant passageways (15) being defined between axially spaced stacks of laminations (4) in the laminated core section, the coolant passageways (15) being connected to the coolant supply duct means (22) through the gap between the stator and the rotor, and

a matrix of coolant duct sections (5) extending circumferentially and axially of the laminated core section (3), a plurality of adjacent coolant duct sections (5) being in fluid communication (11) with each other transverse of the radial direction to transfer coolant in predetermined paths within the coolant duct matrix, the matrix having first and second radially spaced apart faces, the first face being in fluid communication with the radially extending coolant passageways (15) in the laminated core section, characterised in that the second face is in fluid communication with the coolant exhaust duct means (26), such that selected of the coolant duct sections (5) communicate directly with the coolant exhaust duct means (26) through the second face of the matrix.

2. An electrical machine according to claim 1, in which the first and second radially spaced apart faces of the matrix of coolant duct sections (5) comprises its radially inner and outer faces respectively.

3. An electrical machine according to any preceding claim, in which the matrix of coolant duct sections (5) is defined between a plurality of annular side walls (9) which extend radially and circumferentially of the laminated

core section (3) and a plurality of end walls (10) which extend radially and axially of the laminated core section.

4. An electrical machine according to claim 3, in which apertures (11,12) are provided in selected of the side walls (9) and end walls (10) of the coolant duct sections to facilitate the transfer of coolant in the predetermined paths within the coolant duct matrix.

5. An electrical machine according to claim 4, in which the size and number of the apertures (11,12) are selected to achieve desired axial and circumferential pressure differences within the matrix of coolant duct sections (5).

6. An electrical machine according to claim 4 or claim 5, in which each side wall and each end wall has a respective aperture.

7. An electrical machine according to any one of claims 3 to 6, in which a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

8. An electrical machine according to any one of claims 3 to 7, in which the end walls are equi-angularly spaced around the laminated core section.

9. An electrical machine according to any preceding claim, in which each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

10. An electrical machine according to any preceding claim, in which the coolant supply duct means defines a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path

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European Patent Office
acting as International Preliminary Examining Authority
D-80298 München
Germany

Attn: P Torlai

10 September 2001

INTERNATIONAL PATENT APPLICATION NO. PCT/GB00/03375
Our Ref: P/70036.WOP/LML

Further to the Written Opinion dated 08.08.2001, Applicants respond as follows.

1. Claim 1 has been put into the two-part form and reference numbers have been inserted in claims 1-5 as requested by the Examiner. The order of the clauses in claim 1 has been rearranged so that the pre-characterising part of the claim is directed to the arrangement disclosed in document D1 (GB 1 218 774). Other minor amendments have been made to claims 1, 2, 3 and 5 on pages 15 and 16 for consistency of terminology. Corresponding amendments have been made on pages 2 and 3. For the convenience of the Examiner, all amendments are specifically highlighted on the attached pages by ~~strikeout~~ for deletions and **bold underlined** for insertions. Fair copies of amended pages 2, 3, 15 and 16 are also enclosed in triplicate with the confirmation copy of this letter.

2. In our opinion, document D1 does not disclose a matrix of coolant duct sections with the same characteristics as defined our claim 1. Our claim says, in effect, that the first face of the matrix communicates with the stator core passages and the second face of the matrix communicates with the coolant exhaust ducts and that some of the coolant duct sections in the matrix communicate directly with the coolant exhaust ducts through the second (i.e., for stator cores, radially outer) face of the matrix. However, though D1 discloses direct communication of cooling duct sections with stator core passages, it doesn't disclose direct communication of cooling duct sections with coolant exhaust ducts through the second face of the matrix. Hence, the citation does not anticipate our construction as claimed in claim 1. This construction is advantageous ,e.g., in facilitating improved cooling of electrical machines in situations where cooling air must be conveyed away from the machine in a non-axial direction.

3. We also note that D1 fails to anticipate our claim 3, considered *per se*, in that D1's cooling duct matrix is not divided into sections circumferentially of the core by radially and axially

extending end walls. Our claim 3 construction further facilitates selection of an optimised cooling path through the matrix.

4. The other citations fail to supply the above-noted deficiencies in the disclosure of D1. *Inter alia*, D2 (US 3 171 996) does not have coolant exhaust duct means in fluid communication with the second face of a matrix of coolant duct sections, as required by our claim 1.
5. In the amended claim 1 filed with this letter, the use of the functional linking statement "such that" is believed to be proper because together with the following clause it further defines the structural characteristics of the coolant duct matrix.

Yours faithfully,

L P Dargavel
Agent for the Applicants

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England

passageways will adjoin with the air gap between the rotor and stator. Our published patent document GB 2 338 350 A discusses how to define such passageways more advantageously in terms of the cooling effect they can produce.

Whilst such an arrangement allows the passage of cooling fluid from the inside to the outside (or from the outside to the inside) of the rotor or stator, it has been found that the cooling effect that is provided is insufficiently controlled to produce even cooling over the entire circumferential and axial extent of the rotor or stator. In an electrical rotating machine even cooling is essential in order to avoid localised overheating of windings, thus enabling increased power densities to be obtained.

It is an object of the present invention to provide an arrangement whereby a more controlled cooling of the machine can be achieved.

Accordingly, the invention provides an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator ~~or~~**and** the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the radial passageways being connected to the coolant supply duct means *via* the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, **a plurality of adjacent coolant duct sections being in fluid communication with each other transverse of the radial direction to transfer coolant in predetermined paths within the**

coolant duct matrix, the matrix having first and second radially spaced apart faces ~~respectively~~**, the first face being** in fluid communication with the radially extending coolant passageways in the laminated core section ~~and~~**, characterised in that** the **second face is in fluid communication with the** coolant exhaust duct means, ~~wherein~~**such that** selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix ~~and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix~~..

In one possible arrangement of the machine, the first and second radially spaced apart faces of the ~~duct~~ matrix **of coolant duct sections** comprises its radially inner and outer faces respectively.

The matrix of coolant duct sections is conveniently defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the **laminated** core section. To facilitate the transfer of coolant in the predetermined path within the coolant duct matrix, apertures are provided in selected of the side walls and end walls of the coolant duct sections. The size and number of the apertures are preferably selected to achieve desired axial and circumferential pressure differences within the ~~coolant duct~~ matrix **of coolant duct sections**. It is possible that each side wall and each end wall will have a respective aperture, but this will be determined by detailed design using computational flow analysis.

In a preferred embodiment of the invention, in which the coolant duct sections are defined as above, a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

The end walls may be equi-angularly spaced around the laminated core section.

CLAIMS

1. An electrical machine **(1)** comprising a stator **(2)** and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means **(22)** and coolant exhaust duct means **(26)**,

a plurality of substantially radially extending coolant passageways **(15)** provided in a laminated core section **(3)** of at least one of the stator ~~or~~ **and** the rotor, the coolant passageways **(15)** being defined between axially spaced stacks of laminations **(4)** in the laminated core section, the coolant passageways **(15)** being connected to the coolant supply duct means **(22)** through the gap between the stator and the rotor, and

a matrix of coolant duct sections **(5)** extending circumferentially and axially of the laminated core section **(3)**, **a plurality of adjacent coolant duct sections (5) being in fluid communication (11) with each other transverse of the radial direction to transfer coolant in predetermined paths within the coolant duct matrix,** the matrix having first and second radially spaced apart faces ~~respectively~~**, the first face being** in fluid communication with the radially extending coolant passageways **(15)** in the laminated core section ~~and~~**, characterised in that** the **second face is in fluid communication with the** coolant exhaust duct means **(26)**, ~~wherein~~**such that** selected of the coolant duct sections **(5)** communicate directly with the coolant exhaust duct means **(26)** through the second face of the matrix ~~and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix~~.

2. An electrical machine according to claim 1, in which the first and second radially spaced apart faces of the ~~duct~~ matrix **of coolant duct sections (5)** comprises its radially inner and outer faces respectively.

3. An electrical machine according to any preceding claim, in which the matrix of coolant duct sections **(5)** is defined between a plurality of annular side walls **(9)** which extend radially and circumferentially of the laminated core section **(3)** and a plurality of end walls **(10)** which extend radially and axially of the **laminated** core section.

4. An electrical machine according to claim 3, in which apertures **(11,12)** are provided in selected of the side walls **(9)** and end walls **(10)** of the coolant duct sections to facilitate the transfer of coolant in the predetermined path**s** within the coolant duct matrix.

5. An electrical machine according to claim 4, in which the size and number of the apertures **(11,12)** are selected to achieve desired axial and circumferential pressure differences within the ~~coolant duct~~ matrix **of coolant duct sections (5)**.

6. An electrical machine according to claim 4 or claim 5, in which each side wall and each end wall has a respective aperture.

7. An electrical machine according to any one of claims 3 to 6, in which a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

8. An electrical machine according to any one of claims 3 to 7, in which the end walls are equi-angularly spaced around the laminated core section.

9. An electrical machine according to any preceding claim, in which each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

10. An electrical machine according to any preceding claim, in which the coolant supply duct means defines a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path

passageways will adjoin with the air gap between the rotor and stator. Our published patent document GB 2 338 350 A discusses how to define such passageways more advantageously in terms of the cooling effect they can produce.

Whilst such an arrangement allows the passage of cooling fluid from the inside to the outside (or from the outside to the inside) of the rotor or stator, it has been found that the cooling effect that is provided is insufficiently controlled to produce even cooling over the entire circumferential and axial extent of the rotor or stator. In an electrical rotating machine even cooling is essential in order to avoid localised overheating of windings, thus enabling increased power densities to be obtained.

It is an object of the present invention to provide an arrangement whereby a more controlled cooling of the machine can be achieved.

Accordingly, the invention provides an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator and the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the radial passageways being connected to the coolant supply duct means *via* the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, a plurality of adjacent coolant duct sections being in fluid communication with each other transverse of the

radial direction to transfer coolant in predetermined paths within the coolant duct matrix, the matrix having first and second radially spaced apart faces, the first face being in fluid communication with the radially extending coolant passageways in the laminated core section, characterised in that the second face is in fluid communication with the coolant exhaust duct means, such that selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix.

In one possible arrangement of the machine, the first and second radially spaced apart faces of the matrix of coolant duct sections comprises its radially inner and outer faces respectively.

The matrix of coolant duct sections is conveniently defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the laminated core section. To facilitate the transfer of coolant in the predetermined path within the coolant duct matrix, apertures are provided in selected of the side walls and end walls of the coolant duct sections. The size and number of the apertures are preferably selected to achieve desired axial and circumferential pressure differences within the matrix of coolant duct sections. It is possible that each side wall and each end wall will have a respective aperture, but this will be determined by detailed design using computational flow analysis.

In a preferred embodiment of the invention, in which the coolant duct sections are defined as above, a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

The end walls may be equi-angularly spaced around the laminated core section.

CLAIMS

1. An electrical machine (1) comprising a stator (2) and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means (22) and coolant exhaust duct means (26),

a plurality of substantially radially extending coolant passageways (15) provided in a laminated core section (3) of at least one of the stator and the rotor, the coolant passageways (15) being defined between axially spaced stacks of laminations (4) in the laminated core section, the coolant passageways (15) being connected to the coolant supply duct means (22) through the gap between the stator and the rotor, and

a matrix of coolant duct sections (5) extending circumferentially and axially of the laminated core section (3), a plurality of adjacent coolant duct sections (5) being in fluid communication (11) with each other transverse of the radial direction to transfer coolant in predetermined paths within the coolant duct matrix, the matrix having first and second radially spaced apart faces, the first face being in fluid communication with the radially extending coolant passageways (15) in the laminated core section, characterised in that the second face is in fluid communication with the coolant exhaust duct means (26), such that selected of the coolant duct sections (5) communicate directly with the coolant exhaust duct means (26) through the second face of the matrix.

2. An electrical machine according to claim 1, in which the first and second radially spaced apart faces of the matrix of coolant duct sections (5) comprises its radially inner and outer faces respectively.

3. An electrical machine according to any preceding claim, in which the matrix of coolant duct sections (5) is defined between a plurality of annular side walls (9) which extend radially and circumferentially of the laminated

core section (3) and a plurality of end walls (10) which extend radially and axially of the laminated core section.

4. An electrical machine according to claim 3, in which apertures (11,12) are provided in selected of the side walls (9) and end walls (10) of the coolant duct sections to facilitate the transfer of coolant in the predetermined paths within the coolant duct matrix.

5. An electrical machine according to claim 4, in which the size and number of the apertures (11,12) are selected to achieve desired axial and circumferential pressure differences within the matrix of coolant duct sections (5).

6. An electrical machine according to claim 4 or claim 5, in which each side wall and each end wall has a respective aperture.

7. An electrical machine according to any one of claims 3 to 6, in which a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

8. An electrical machine according to any one of claims 3 to 7, in which the end walls are equi-angularly spaced around the laminated core section.

9. An electrical machine according to any preceding claim, in which each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

10. An electrical machine according to any preceding claim, in which the coolant supply duct means defines a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
P/70036/LML		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/ 03375	01/09/2000	01/09/1999
Applicant		
ALSTOM UK LTD		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   AIR COOLED ELECTRICAL MACHINE

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [X] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03375

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K1/20 H02K9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 218 774 A (GENERAL ELECTRIC) 13 January 1971 (1971-01-13)	1,2, 9-11,13, 18,19
Y	page 2, line 21 - line 62 figure 1	14-17,20
Y	US 3 171 996 A (GENERAL ELECTRIC) 2 March 1965 (1965-03-02) column 3, line 45 - line 75 figures 1-6	14-17
Y	EP 0 590 867 A (KVAERNER MASA YARDS OY) 6 April 1994 (1994-04-06) claim 1 figure 2	20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2000	11/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Foussier, P

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03375

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 1 792 720 A (ALLIS-CHALMERS MANUFACTURING) 17 February 1931 (1931-02-17)	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/03375

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1218774 A	13-01-1971	CH 504803 A	15-03-1971
		DE 1814431 A	24-07-1969
		FR 1599338 A	15-07-1970
		US 3461330 A	12-08-1969
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		JP 6191484 A	12-07-1994
		NO 933441 A	29-03-1994
		RU 2097266 C	27-11-1997
		SG 43165 A	17-10-1997
		US 5403216 A	04-04-1995
US 1792720 A	17-02-1931	NONE	

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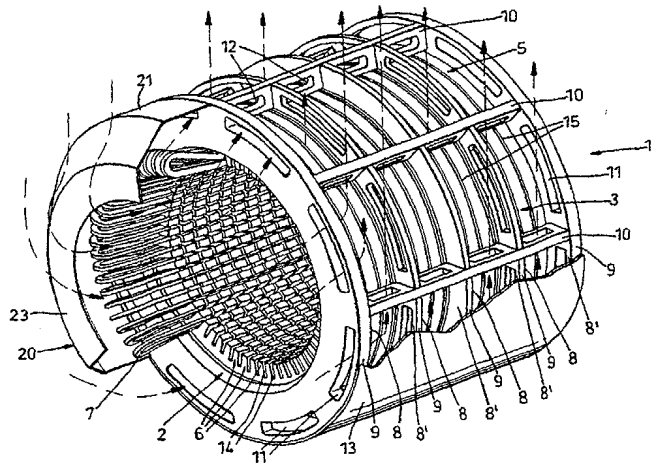
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: AIR COOLED ELECTRICAL MACHINE



(57) Abstract: An electrical machine (1) comprising a stator (2) and a rotor has radially extending coolant passageways (15) provided in a laminated core section (3) of at least the stator, the coolant passageways (15) being defined between axially spaced stacks of laminations in the laminated core section. The radial passageways are connected to coolant supply duct means (22) through the gap between the stator and the rotor. More efficient cooling of the machine is obtained by providing a matrix of coolant duct sections (5) extending circumferentially and axially of the core section (3), the matrix having first and second radially spaced apart faces respectively in fluid communication with the radially extending coolant passageways (15) in the laminated core section (3) and coolant exhaust ducts (26). Some of the coolant duct sections (5) communicate directly with the coolant exhaust ducts (26) through the second face of the matrix and some or all of the adjacent coolant duct sections (5) are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

WO 01/17094 A1

AIR COOLED ELECTRICAL MACHINE

This invention relates to improvements in cooling arrangements for rotating electrical machines. More particularly, the invention is concerned with the efficient cooling of such machines

The term "rotating electrical machine" is intended to cover any form of apparatus having a rotating member which generates, converts, transforms or modifies electric power, *inter alia*, such machines will comprise motors, generators, synchronous condensers, synchronous converters, rotating amplifiers, phase modifiers and combinations of these in any one machine.

With increasing development of permanent magnets and the use of exotic materials in machines, it is now possible to produce relatively high power/high torque motors which occupy far less space than equivalent machines of, say, five years earlier. This reduction in size brings with it an increase in complexity in cooling the machines. Heat dissipation is also a problem with machines that do not employ permanent magnets. The more efficient the cooling, the higher the power density and hence smaller the machine that can be produced.

In a normal arrangement, it is known to provide a laminated component which forms a part of the stator of the machine. This is typically formed from stacks of sheets of electrical grade steel which are often provided with insulating coatings. Each sheet may, for example, be of generally disc or annular form.

Between stacks of the sheets are often provided passageways for cooling fluid, e.g. air, which passageways extend substantially radially. More particularly, in a typical machine the radial inner or outer ends of the

passageways will adjoin with the air gap between the rotor and stator. Our published patent document GB 2 338 350 A discusses how to define such passageways more advantageously in terms of the cooling effect they can produce.

Whilst such an arrangement allows the passage of cooling fluid from the inside to the outside (or from the outside to the inside) of the rotor or stator, it has been found that the cooling effect that is provided is insufficiently controlled to produce even cooling over the entire circumferential and axial extent of the rotor or stator. In an electrical rotating machine even cooling is essential in order to avoid localised overheating of windings, thus enabling increased power densities to be obtained.

It is an object of the present invention to provide an arrangement whereby a more controlled cooling of the machine can be achieved.

Accordingly, the invention provides an electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator or the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the radial passageways being connected to the coolant supply duct means *via* the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, the matrix having first and second radially spaced apart faces respectively in fluid communication with the

radially extending coolant passageways in the laminated core section and the coolant exhaust duct means, wherein selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

In one possible arrangement of the machine, the first and second radially spaced apart faces of the duct matrix comprises its radially inner and outer faces respectively.

The matrix of coolant duct sections is conveniently defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the core section. To facilitate the transfer of coolant in the predetermined path within the coolant duct matrix, apertures are provided in selected of the side walls and end walls of the coolant duct sections. The size and number of the apertures are preferably selected to achieve desired axial and circumferential pressure differences within the coolant duct matrix. It is possible that each side wall and each end wall will have a respective aperture, but this will be determined by detailed design using computational flow analysis.

In a preferred embodiment of the invention, in which the coolant duct sections are defined as above, a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

The end walls may be equi-angularly spaced around the laminated core section.

Preferably, each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

Advantageously, the coolant supply duct means may define a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path from the plenum chamber to the radially extending coolant passageways in the laminated core section. From a practical design point of view, it is preferable if the coolant supply duct means defines coolant supply paths directed towards both axial ends of the laminated core section through respective plenum chambers.

It is particularly advantageous for cooling end windings of the laminated core section if apertures in at least one of the end plates of the laminated core section provide a coolant flow path from the plenum chamber to selected of the coolant duct sections in the matrix, since the coolant can flow past the end windings on the way to the matrix.

The invention particularly facilitates designs in which at least one of the coolant supply duct means and the coolant exhaust duct means extends radially of the machine. This is useful where access to the machine is confined to certain angular positions around the machine.

The plurality of substantially radially extending coolant passageways provided in the laminated core section preferably comprise axially thin annular ducts. In accordance with our published patent document GB 2,338,350 A, the axially thin annular ducts can be defined by spacer means provided between adjacent confronting stacks of laminations in the

laminated core section. The spacer means may thus comprise a pattern of mutually spaced apart axially projecting generally cylindrical members attached to at least one of the confronting laminations, the pattern extending between radially inner and outer peripheries of the confronting laminations. The pattern of generally cylindrical members may extend throughout the total annular extent of the passageway.

It should be noted that the matrix of coolant duct sections preferably extends around the entire circumference of the laminated core section.

It is convenient for layout of radially extending exhaust ducts if the coolant duct sections which communicate directly with the exhaust duct means comprise approximately half the circumferential extent of the matrix.

The invention further provides an electrical machine as described above, comprising a propulsion unit for a ship in which the machine is located within a bulbous portion extending from a hull of the ship, the rotor of the machine being located on a propeller shaft which extends outside the bulbous portion for propulsion of the ship, the coolant supply duct means and the coolant exhaust duct means being arranged within the bulbous portion to supply and exhaust coolant through the ship's hull.

It will be understood that by radially extending coolant passageways provided in the laminated core section, we mean passageways along which fluid can move from a first radial position to a second radial position. This may be from the innermost to outermost perimeter of the stator or rotor, or *vice-versa*. During such movement in radial passageways designed in accordance with our prior published patent document GB 2,338,350 A, it is envisaged that a substantial circumferential movement will also occur, due to the relative rotation between the rotor and stator, but primarily due to the

influence of the circumferential pressure differences developed within the matrix of cooling duct sections. The fluid may even have a greater circumferential velocity than radial velocity on moving through such radial passageways.

By providing a circumferential matrix of coolant duct sections around the laminated core of the rotor or stator it is possible to control the passage of fluid through the machine to optimise cooling of the rotor and/or stator in a predetermined manner. This is achieved at the design stage by computational design by varying the size of the openings between each adjacent duct section, thus allowing the cooling flows in the radial passageways to be optimised with respect to the losses in each duct section.

The openings in the walls of the duct sections, e.g., between adjacent duct sections or between the duct sections and the exhaust duct means, may be laser cut into the material. Of course, other cutting methods may be employed.

It will be appreciated that the coolant duct sections do not need to be fabricated from solid plates of material. Other fabrication techniques are envisaged within the scope of the present invention, for example, a honeycomb sandwich or expanded metal construction could be used to produce the dividing walls.

In a preferred arrangement, the machine includes a stator extending around the outside of a rotor, the stator having radial passageways and the matrix of coolant duct sections extending around the outside of the stator. In an alternative arrangement, the matrix may extend around the inside of the rotor with the rotor having radial cooling passageways and rotating within

the stator. In yet a further arrangement, the rotor may rotate around the stator with the matrix being provided around the outside of the rotor.

The matrix of cooling duct sections may comprise an integral part of the laminated core section of the machine. It may alternatively form a sleeve which is adapted to be secured around the circumference of the laminated core section. This may or may not be removable in use.

The combination of the arrangement of the radial passageways and their cylindrical members and the apertures in the walls between the duct sections is preferably chosen to maintain a substantially uniform temperature throughout the machine during normal operation.

The provision of the duct sections and their interconnecting holes ensures that the cooling fluid can travel a significant circumferential distance between entering the machine and leaving the machine. This enables the coolant for the machine to be supplied and exhausted from any desired circumferential location on the machine.

There will now be described, by way of example only, embodiments of the present invention with reference to the accompanying drawings, in which:

Figure 1 is an isometric view in partial cross-section of a rotating electrical machine in accordance with one aspect of the present invention;

Figure 2 is a side view of the machine of Figure 1, again shown partially cut-away;

Figure 3 is an enlarged cut-away view of the machine of Figure 1 showing the location of cylindrical members within radial passageways of the stator; and

Figure 4 is an isometric view illustrating one possible form of ducting and casing surrounding the machine of Figures 1 to 3, whereby cooling air may be supplied to and exhausted from the machine.

As shown in Figures 1 to 3 of the accompanying drawings, the machine 1 comprises a rotor (not shown) which is adapted to rotate within an annular stator assembly 2. The rotor has a rotational axis A-A (Figure 2), coinciding with the longitudinal axis of the stator. In alternatives, the machine may comprise a rotor which rotates around the outside of an annular stator.

The stator assembly 2 comprises an inner laminated core section 3 comprised of a plurality of axially spaced annular stacks 4 of laminations of electrical steel. This is surrounded by an outer matrix of coolant duct sections 5 having walls 9, 9^1 and 10, fabricated from plates or sheets of material.

Each lamination of the stator comprises a thin, generally annular sheet member, with the inner circumference of each lamination, and therefore each stack 4 of laminations, being provided with generally radially inwardly extending teeth 6. Each pair of adjacent teeth 6 define therebetween a slot 14 to hold one or more windings 7 of the stator. For clarity of illustration, only the looped ends of some of the windings 7 are shown projecting from the slots 14, the rest of the length of the windings being omitted. It should be noted that certain designs of machine, e.g., superconducting machines, may not have the windings located in slots.

The stacks 4 of laminations as shown in Figure 3 are separated by spacers in the form of cylindrical members 18 affixed to a face of an end lamination of each stack 4, as described in more detail in our prior patent specification GB 2 338 350 A. Thus, radially extending cooling passageways 15 in the form of axially thin annular ducts are defined between adjacent stacks with the cylindrical members 18 occupying the passageways with the axes of the members extending transversely across the passageways 15, e.g., substantially parallel to the axis A-A of the stator 2.

Around the outside periphery of the stator inner laminated core section is provided the circumferentially and axially extending matrix of coolant duct sections 5. The matrix can be characterised as having first and second radially spaced apart faces; the first or radially inner face of the matrix interfaces with the laminated core section 3 so that the matrix is in communication with the radial passageways 15, and the second or radially outer face of the matrix interfaces with a casing 13, through which it communicates with exhaust ducts, as explained later.

Within the matrix, each duct section 5 has side walls defined by confronting faces 8, 8^1 of axially spaced apart annular plates 9 or 9^1 of, e.g., mild steel which lie in radial planes perpendicular to the stator axis A-A. In the illustrated embodiment, five such annular plates are provided, the two end plates 9^1 being of greater thickness than the others to function as load-bearing end plates for the stator. The spacing between the side walls 8, 8^1 in this embodiment is such as to embrace four radial passageways 15, but the number of passageways so embraced could be more or less at the option of the designer, taking into account the volume of the coolant flows required to be managed by the duct sections 5 for any particular machine.

The circumferentially extending duct sections 5 defined between confronting side walls 8, 8^1 are further defined by radially and axially extending end walls 10, which have a radial depth equal to that of the annular side wall plates 9^1 and an axial width equal to the spacing between the side walls 8, 8^1. The end walls in the present embodiment are equi-angularly spaced apart around the core section 3. The side walls 9 and 9^1 and end walls 10 are fixed together, e.g., by welding, to form a rigid matrix of coolant duct sections 5 which extends circumferentially and axially around the stator. In the particular embodiment shown, eight radial end walls 10 are provided, so defining a total of thirty two circumferential duct sections 5 in the matrix.

As shown, a respective elongate opening 11 is provided in each side wall 9, 9^1 of the ducts 5, as well as an opening 12 in each of the end walls 10. The "tops" of the coolant duct sections 5, which together constitute the before-menntioned radially outer face of the matrix, are covered by a surrounding casing 13 which is shown cut-away; however, at least some of the duct sections on the upper half of the stator are only partly covered by casing 13, or even completely uncovered, apertures (not shown) being provided in the casing 13 as appropriate, so that these partially or completely uncovered duct sections connect to ducting 26 shown in Figure 4 for exhaustion of the used cooling air from the stator, as further explained below. In this embodiment, the "bottoms" of all the duct sections 5 – which together constitute the radially inner face of the matrix which interfaces with the laminated core section 3 – are left open for free fluid connection to the radial passageways 15 between the stacks 4 of core laminations.

An annular end cap 20 is shown as provided on one end of the stator, though it is preferably provided at both ends, as explained later. It has an axially and circumferentially extending peripheral wall 21 fixed at the outer circumference of the end plate 9^1 of the stator and joined by a frusto-conical

portion to a radially extending inwardly directed end wall 23 distal from the stator. The radial wall 23 defines a central circular hole for supply of coolant to the machine and to allow the rotor to be mounted on a shaft. The end cap 20, in conjunction with the ends of the rotor and stator, defines a plenum chamber for the supply of coolant to the machine.

In operation, coolant such as air, as indicated by the dashed arrows, is pumped axially into the centre of the stator through the plenum chamber defined by the end cap 20. From there, it flows through the stator by two different routes. By one route it flows between the end windings 7 to cool them and then through the openings 11 in the end wall 9^1 of the stator into the adjacent duct sections 5. By the other route it flows into the air gap between the rotor and stator. From the air gap it enters the radial passageways 15 defined in the inner laminated core section 3 of the machine. Coolant then flows through the radial passageways 15, past the cylindrical members 18, and outwards into the matrix of duct sections 5. Once the coolant has reached the matrix, it can also flow from one duct section 5 to its axially or circumferentially adjacent duct section 5 through the openings 11, 12 in the duct walls 9, 10. From the duct sections 5 in the upper half of the stator's circumference, the coolant can flow into the exhaust ducts 26 (Figure 4) through uncovered or partially covered peripheries of the duct sections.

By careful design of the size of the openings 11,12 in the walls 9, 9^1 and 10 of the duct sections, as well as the spacing and size of adjacent duct sections, accurate control of the cooling of the stator can be achieved to ensure a predetermined efficient cooling pattern is maintained. This accuracy of control has been found to be considerably more refined than a design in which the coolant duct matrix is omitted.

Although Figures 1 to 3 show openings in each end wall and side wall, not all the walls necessarily need openings. In this manner, by omitting or restricting selected of the openings 11, 12, and also by covering or (optionally partially) uncovering selected of the duct sections 5 on the upper half of the stator, a predetermined route which air can take around the stator can be defined. For example, those duct sections 5 in the upper part of the machine which are uncovered, or only partly covered, so as to communicate with exhaust ducts, will have a lower coolant pressure than the duct sections in the lower part of the machine which are fully covered by the casing 13. This circumferential pressure difference within the coolant duct matrix, which is controlled to a desired value or range of values by means of adjusting (during design of the machine) the sizes of the holes 12, will induce a circumferential component of velocity to the flows of coolant in the duct sections in the lower part of the machine, and also within the radial passages 15. In the latter connection, it should be noted that the movement of the rotor relative to the stator imparts a circumferential component to the coolant flow in the gap between rotor and stator. This circumferential component is transferred to the radial passageways 15 and may either assist or hinder the imparting of circumferential velocity components by the duct sections 5, as explained above.

It will also now be evident to the specialist that by selecting the sizes of the holes 11 in the side walls 9 of the duct sections, axial pressure differences within the cooling duct matrix can be created as desired, thereby to transfer coolant between axially adjacent duct sections, as deemed appropriate by the designer to achieve optimum coolant flows through the machine.

Referring now in particular to Figure 4, there is shown a scheme for housing a machine having a stator like that described above and for supplying and exhausting coolant, preferably air, to and from duct sections at the top of

the machine. Air is supplied through ducts 22 and 24 to both ends of the machine and hence each end is provided with an end cap 20, one end cap being shown in partial cut-away view within supply duct 22. The end caps ensure the coolant is supplied axially to the stator and rotor end windings and to the air gap between the rotor and stator. After passing through the stator in the manner already described, the coolant passes out of partially or completely uncovered duct sections in the top half of the stator into the twin exhaust ducts 26, as previously discussed.

The layout shown is particularly suited to a propulsion unit for a high power ship. The casing 13 may be located within a bulbous portion extending from the hull of the ship (not shown) and the propulsion unit may comprise the stator described in relation to Figures 1 to 3, together with a rotor 27 located within the stator on a tubular propeller shaft 28, these components being indicated in partial view by dashed lines. The tubular shaft 28 extends out of casing 13 through a hole 29 and connects to a propeller (not shown) outside the bulbous portion whereby rotation of the rotor 27 produces propulsion of the ship. If desired, the propulsion unit may be located eccentrically within the bulbous portion closer to the bottom of the bulbous portion, with ducts 22, 24, 26 being arranged within the bulbous portion to supply and exhaust coolant through the ship's hull.

The effect of the coolant duct sections 5 in imparting a significant circumferential component of velocity to the coolant flow as explained above, ensures that the coolant can travel through a significant angular distance between entering the machine and leaving the machine, thus enabling the coolant to be supplied to and exhausted from any convenient angular position on the machine. Hence, alternative modes of supplying and exhausting the coolant to and from the machine can be envisaged, e.g., for a rolling mill drive or mine-winder motor, in which the coolant supply and

exhaust ducts could connect to the matrix of coolant duct sections at the bottom or sides of the machine. The exact configuration will depend upon the available space surrounding the machine. It will therefore be realised that whereas Figure 4 shows the supply ducts 22, 24 and the exhaust ducts 26 arranged in an "in-line" configuration, they could occupy different angular positions around the circumference of the machine.

Whilst the embodiment illustrated is of a stator of a motor it will be appreciated that the invention may also be applied to a generator or any other electrical rotating machine in which it is important to provide accurate controlled cooling of the components of the machine. The matrix of coolant duct sections may be located around the outside of the machine as shown, or in the case of a machine in which coolant flows inwardly from a peripheral location and is exhausted from a central part of the machine, the coolant duct matrix may extend around an inner circumference of the machine if required.

CLAIMS

1. An electrical machine comprising a stator and a rotor, with a gap defined between the stator and the rotor, the machine further comprising;

coolant supply duct means and coolant exhaust duct means,

a plurality of substantially radially extending coolant passageways provided in a laminated core section of at least one of the stator or the rotor, the coolant passageways being defined between axially spaced stacks of laminations in the laminated core section, the coolant passageways being connected to the coolant supply duct means through the gap between the stator and the rotor, and

a matrix of coolant duct sections extending circumferentially and axially of the laminated core section, the matrix having first and second radially spaced apart faces respectively in fluid communication with the radially extending coolant passageways in the laminated core section and the coolant exhaust duct means, wherein selected of the coolant duct sections communicate directly with the coolant exhaust duct means through the second face of the matrix and a plurality of adjacent coolant duct sections are in fluid communication with each other transverse of the radial direction to transfer coolant in a predetermined path within the coolant duct matrix.

2. An electrical machine according to claim 1, in which the first and second radially spaced apart faces of the duct matrix comprises its radially inner and outer faces respectively.

3. An electrical machine according to any preceding claim, in which the matrix of coolant duct sections is defined between a plurality of annular side walls which extend radially and circumferentially of the laminated core section and a plurality of end walls which extend radially and axially of the core section.

4. An electrical machine according to claim 3, in which apertures are provided in selected of the side walls and end walls of the coolant duct sections to facilitate the transfer of coolant in the predetermined path within the coolant duct matrix.

5. An electrical machine according to claim 4, in which the size and number of the apertures are selected to achieve desired axial and circumferential pressure differences within the coolant duct matrix.

6. An electrical machine according to claim 4 or claim 5, in which each side wall and each end wall has a respective aperture.

7. An electrical machine according to any one of claims 3 to 6, in which a side wall at each axial end of the matrix constitutes an end plate of the laminated core section.

8. An electrical machine according to any one of claims 3 to 7, in which the end walls are equi-angularly spaced around the laminated core section.

9. An electrical machine according to any preceding claim, in which each coolant duct section communicates directly with a plurality of the radially extending coolant passageways through the first face of the matrix.

10. An electrical machine according to any preceding claim, in which the coolant supply duct means defines a coolant supply path directed towards an axial end of the laminated core section through a plenum chamber axially adjacent the laminated core section, the gap between the rotor and the stator communicating with the plenum chamber to provide a coolant flow path

from the plenum chamber to the radially extending coolant passageways in the laminated core section.

11. An electrical machine according to claim 10, in which the coolant supply duct means defines coolant supply paths directed towards both axial ends of the laminated core section through respective plenum chambers.

12. An electrical machine according to claims 10 or 11 as dependent on claim 7, in which apertures in at least one of the end plates of the laminated core section provide a coolant flow path from the plenum chamber to selected of the coolant duct sections in the matrix.

13. An electrical machine according to any preceding claim, in which at least one of the coolant supply duct means and the coolant exhaust duct means extends radially of the machine.

14. An electrical machine according to any preceding claim, in which the plurality of substantially radially extending coolant passageways provided in the laminated core section comprise axially thin annular ducts.

15. An electrical machine according to claim 14, in which the axially thin annular ducts are defined by spacer means provided between adjacent confronting stacks of laminations in the laminated core section.

16. An electrical machine according to claim 15, in which the spacer means comprise a pattern of mutually spaced apart axially projecting generally cylindrical members attached to at least one of the confronting laminations, the pattern extending between radially inner and outer peripheries of the confronting laminations.

17. An electrical machine according to claim 16, in which the pattern of generally cylindrical members extends throughout the total annular extent of the passageway.

18. An electrical machine according to any preceding claim in which the matrix extends around the entire circumference of the laminated core section.

19. An electrical machine according to any preceding claim in which the coolant duct sections which communicate directly with the exhaust duct means comprise approximately half the circumferential extent of the matrix.

20. An electrical machine according to any preceding claim comprising a propulsion unit for a ship in which the machine is located within a bulbous portion extending from a hull of the ship, the rotor of the machine being located on a propeller shaft which extends outside the bulbous portion for propulsion of the ship, the coolant supply duct means and the coolant exhaust duct means being arranged within the bulbous portion to supply and exhaust coolant through the ship's hull.

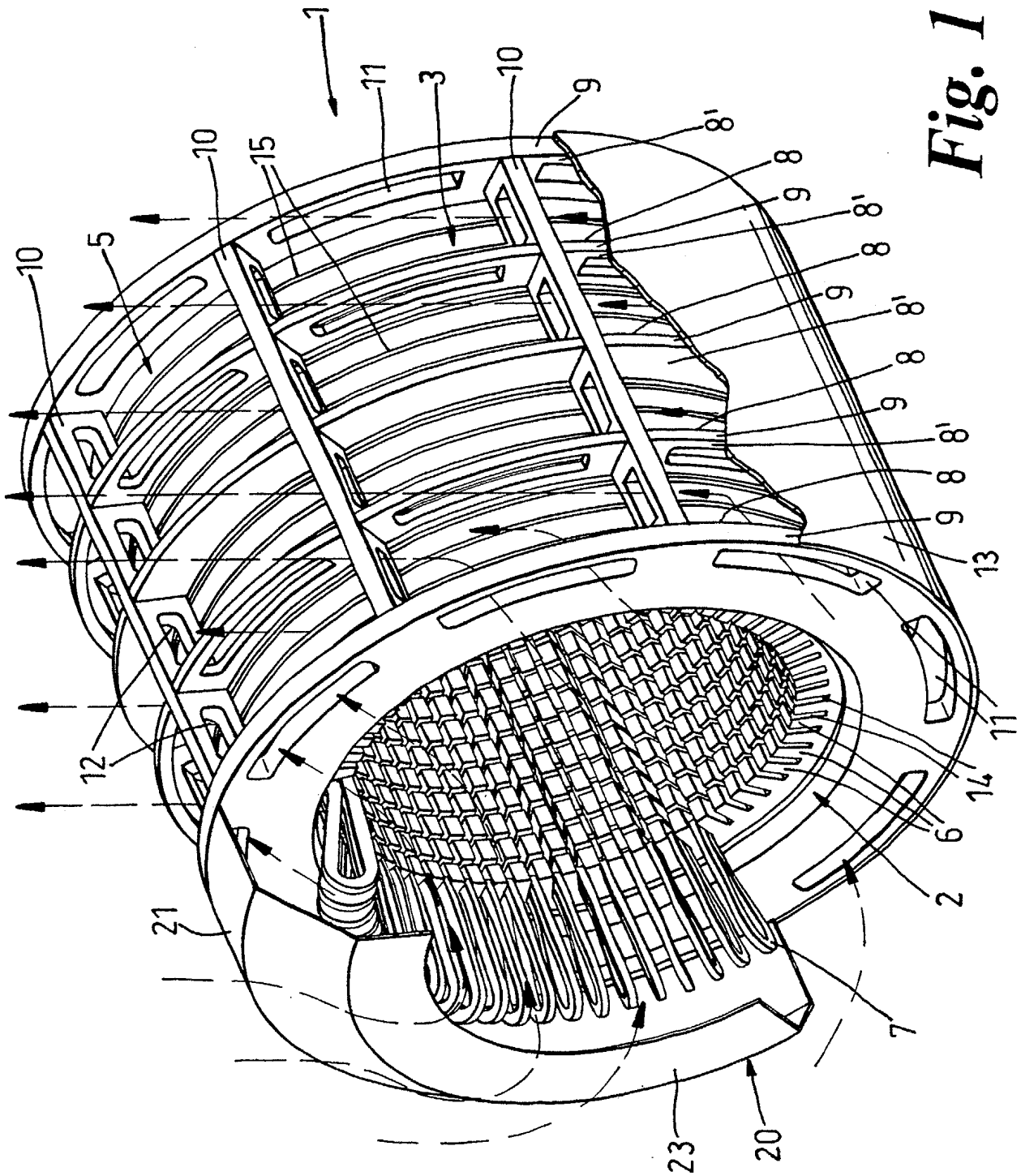


Fig. 1

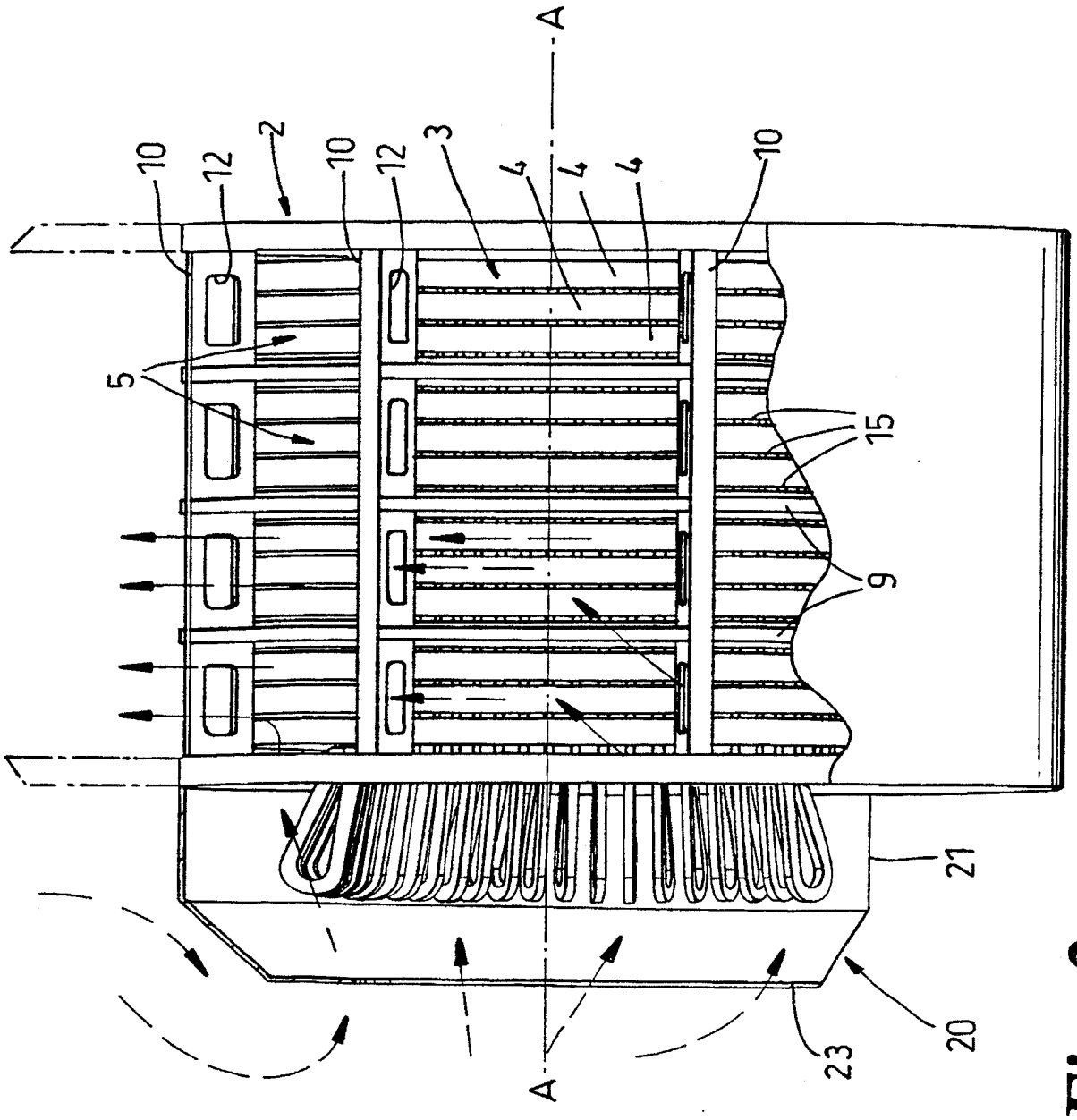


Fig. 2

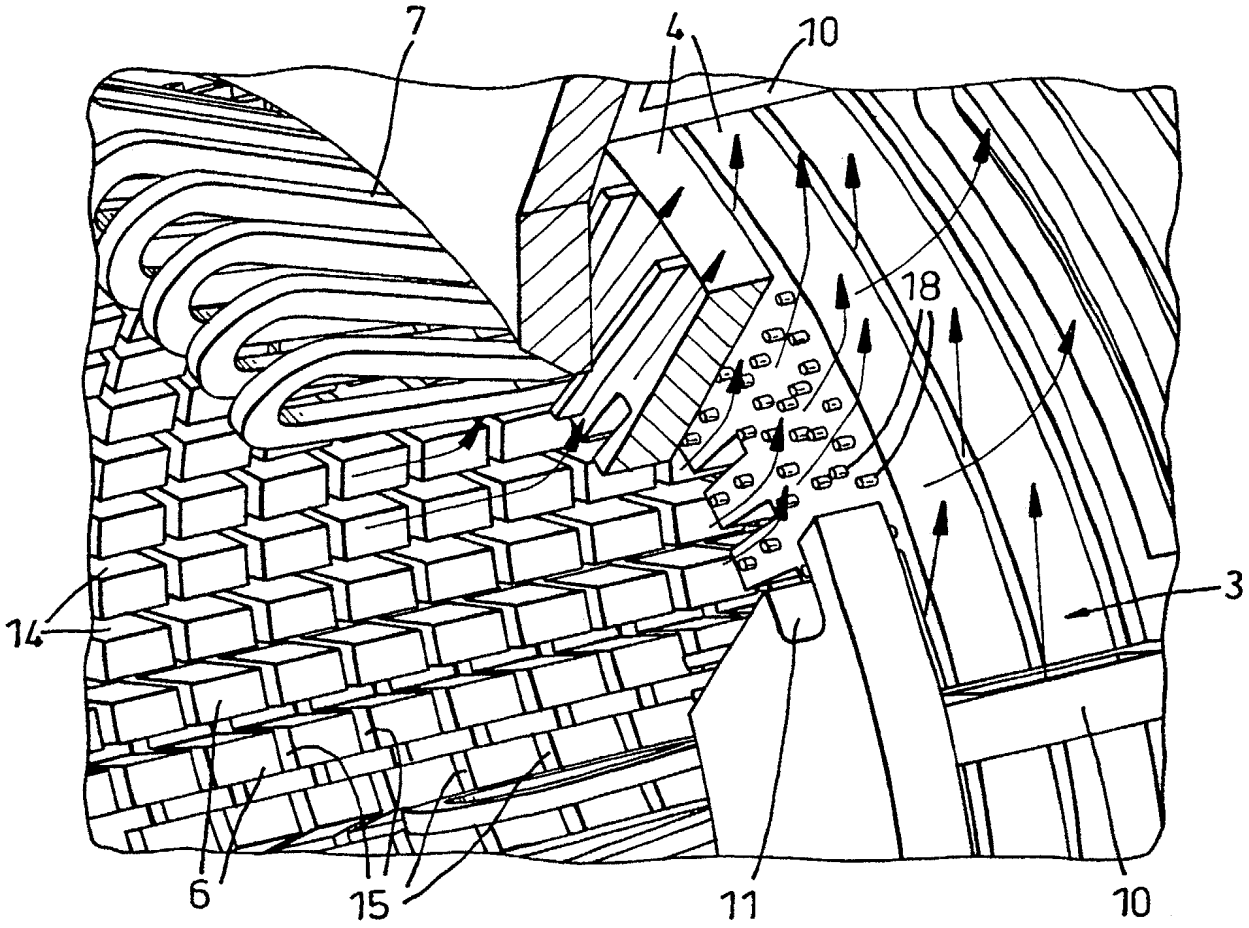


Fig. 3

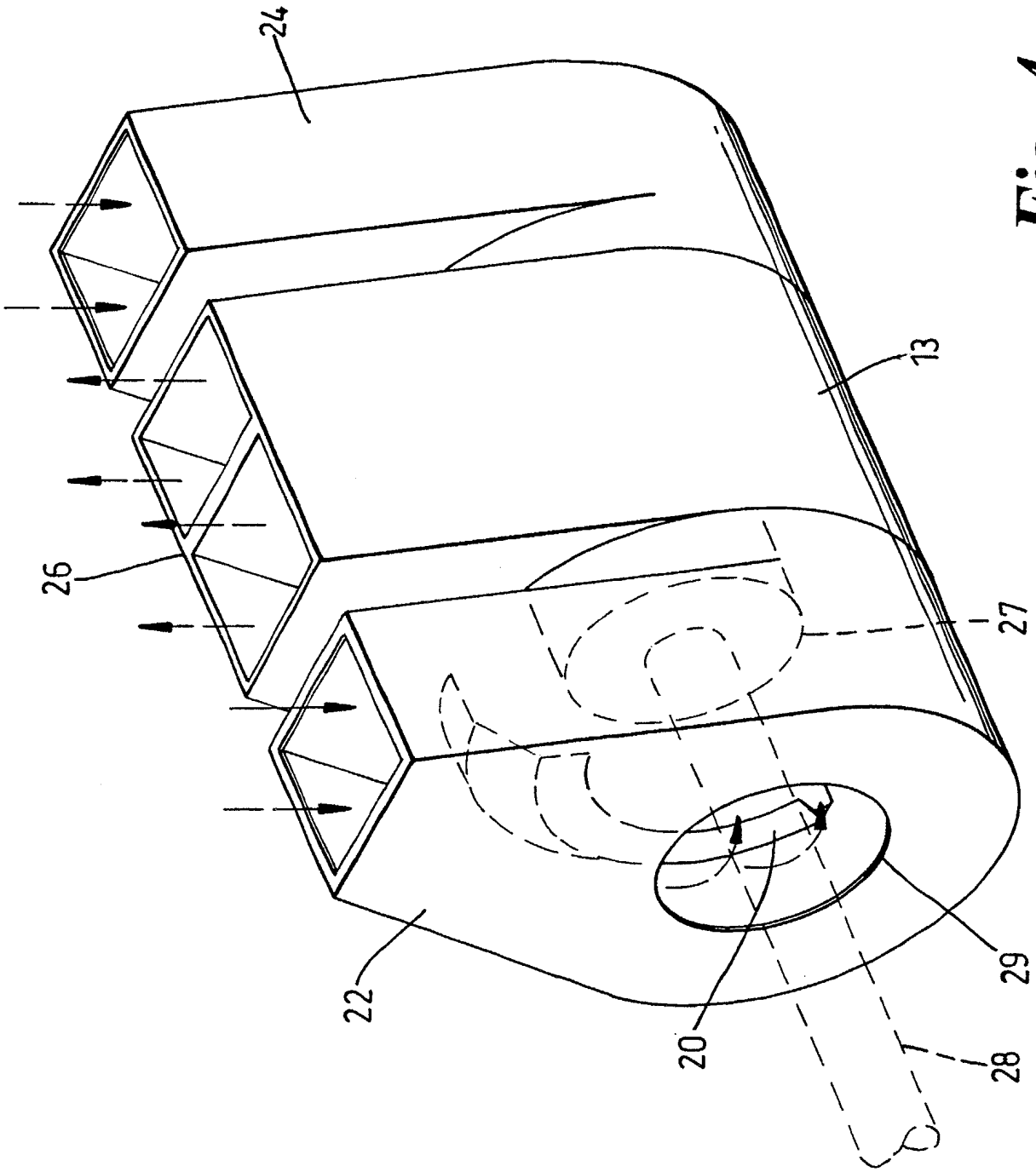


Fig. 4

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/GB 00/03375

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K1/20 H02K9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 218 774 A (GENERAL ELECTRIC) 13 January 1971 (1971-01-13)	1,2, 9-11,13, 18,19
Y	page 2, line 21 - line 62 figure 1	14-17,20

Y	US 3 171 996 A (GENERAL ELECTRIC) 2 March 1965 (1965-03-02) column 3, line 45 - line 75 figures 1-6	14-17

Y	EP 0 590 867 A (KVAERNER MASA YARDS OY) 6 April 1994 (1994-04-06) claim 1 figure 2	20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2000	11/12/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Interr ıal Application No
PCT/GB 00/03375

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